30pP51

Particle and heat flux of the gas target simulation in low density plasma

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The handling of the large heat flux from the core of the fusion reactor become a major issue in designing the future reactor. The experiment which used the high neutral gas pressure to terminate the plasma before reaching the target was carried and the results showed the exponential decrease in the plasma energy flux at the target when the neutral gas pressure increase [1]. This concept is later used in other fusion devices and has been defined as the detached plasma [2].

In this work Particle-in-Cell (PIC) simulation with the Monte Carlo collisions [3] and the cumulative scattering angle coulomb collision [4] are carried out. The PIC simulation can give the insights of the dynamical kinetic behavior of the plasma which are the cooling of plasma, trapped particle effects, and potential structure during the detached plasma.

The pressure and temperature of neutral gas in front of the divertor plate are fixed throughout the simulation run. Thus the dynamics of neutral gas is not included. The real ion-electron mass ratio is used, m_i/m_e = 1836. The simulation system size is L = 0.2 m and the neutral gas box region is between 0 to 0.05 m. The upstream plasma density is limited to $n_u \sim 3\times10^{18}$ m^{-3}. In order to limit the upstream plasma density, the source particle flux is varied in time. Since there is the density threshold for plasma detachment in gas target [5], the Coulomb collision frequency is important for the plasma detachment. In this simulation the plasma density and system size are too small for the detached plasma to be observed, thus the Coulomb collision frequency has been modified $\nu_c=100\nu_{c0}$, where ν_{c0} is the real Coulomb collision frequency [6].

After the various simulation runs is carried out by increasing the neutral gas pressure from 0 to 10 mTorr. The detached plasma can be observed at P_N = 10 mTorr. The electron temperature relaxes toward the ion temperature and strongly decreases inside the neutral gas region ($0 < x < 0.05$ m) to below 1 eV as in Fig. 1. During the relaxation process from 5 to 10 μs the heat load to the divertor target strongly decreases as in Fig. 2.

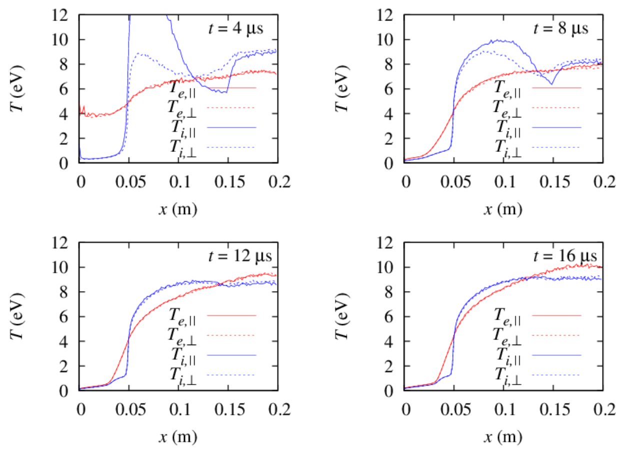

Fig. 1. Electron and Ion temperature profile along the field line at P_N = 10 mTorr.

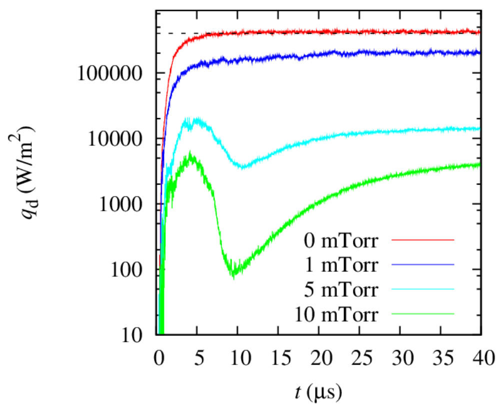

Fig. 2. Time dependent of heat load at divertor target.

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